GEOLOGICAL STRUCTURE OF THE IZU-OGASAWARA ARC AND TRENCH

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Seismic reflection profiles were obtained along the traverse lines of 1,207 sea miles during cruise GH 74–3 using a 120 cubic-inch air-gun at about 2,000 p.s.i.g. with a 10 sec firing rate.

Recording of the 50–150 Hz band was made on a modified RAYTHEON UGR-196B recorder on a 2 or 4 sec scale. The ship speed was approximately 10 knots throughout most of the survey and positioning was based mainly on satellite fixes.

In interpretating the profiles (Fig. 14), the depth below the sea floor to the reflector and the thickness of sedimentary units are presented in two-way travel time, rather than distance (metres), because of the uncertainty of the sonic velocity in the sediments.

a) Line 1–1

The Nishi-Shichito Ridge, which has an irregular surface, is composed mainly of acoustic basement covered by thin transparent layers. Judging from the topography of the basement it is assumed to be igneous. The transparent layers are correlated with those of the Shikoku Basin (MURAUCHI *et al.*, 1973).

Thick sediments (more than 1.5 sec in thickness), which include turbidites, are deposited in the trough between the Nishi-Shichito Ridge and Nishinoshima Island of the Shichito-Iojima Ridge. The trough is separated into two parts by a ridge of acoustic basement, which seems to have been little uplifted since the deposition of the gently folded sediments in the trough. The sediments are inclined and thin out toward the margin of the trough and the sediment layers slightly transgress onto the slope.

The block of Nishinoshima Island is an active volcano, gently tilted westward. Thin

Table 5 Equipments and conditions of the air-gun system.

Air Gun	Model 1900C Par air gun	Bolt Assc. Inc.	Chamber volume Firing pressure	120 cubic inches 2,000 p.s.i.g.
Hydro-streamer	Model GSJ-K-1	Geological Survey	Hydrophone Length of towing cable Ship's speed	15-Geospace MP-17 70 meters 6–10 knots
	Model SC-120	Teledyne exploration Co.	Hydrophone Length of towing cable	50-Recon HP-1 200 meters
Compressor	Model APS-E2-120	Norwalk Co. Inc.	Displacement	120 S.C.F.M.
Amplifier	Model Au-220	Teledyne exploration Co.	Filter settings	50–126 Hz
Recorder	U.G.R. 196B NE-20	Raytheon Co. Nippon electric Co. Ltd.	Sweep range Sweep range	2 or 4 sec/scan 6 sec/scan
Controller	AE-391 Firing Controller	Applied Engineering Co. Ltd.		

opaque layers, presumably composed of pyroclastic rocks, overlie the basement rocks on the slopes of the block.

b) Line 1–2

Irregularly deposited beds are deposited on the lower part of the eastern slope of Nishinoshima Island and may be the result of slumping. In the Ogasawara Trough, turbidites have a thickness of 0.7 sec. Older sediments, having thickness of more than 1.4 sec beneath the turbidites, are gently folded. The basement of these sediments is so deep that it is obscure in the central part of the trough. It was recovered from the eastern margin of the trough beneath the sediments which become thin and climb up toward the margin.

The stratigraphic sequence of the sediments in the Ogasawara Trough is correlated to that in the basin between the Nishi-Shichito Ridge and the Shichito-Iojima Ridge; namely, an upward succession of turbidites and folded sediments from the acoustic basement. There are some faults on the western slope of the Ogasawara Ridge, which are probably normal. The eastward tilted Ogasawara Ridge is composed mainly of old sedimentary rocks intercalated with volcanic rocks, e.g. Paleogene as exposed on Hahajima Island (HANAZAWA, S. 1947). Eastward dipping normal faults occur on the eastern slope of the Ogasawara Ridge.

c) Line 1–3

The western slope of the Izu-Ogasawara Trench is very steep, dipping at about 20°. The slope has three distinct benches at depths of 6.0 sec, 7.5 sec and 9.5 sec. The bottom of the trench is fairly narrow with the width of approximately 3 km, where sediments have a thickness of 0.5 sec.

The eastern slope of the trench rises steeply to a seamount with thin sediment cover.

The abyssal plain is gently inclined towards the trench and is covered by thick transparent layers. Two shallow depressions exist on the plain. One is at the foot of the seamounts and the other is to the east of the former. These depressions appear to cut the transparent layers which suggests that the depressions are upper parts of channels extending into the trench and that sediments might be transported from the oceanic side of the trench in addition to the continental side of it.

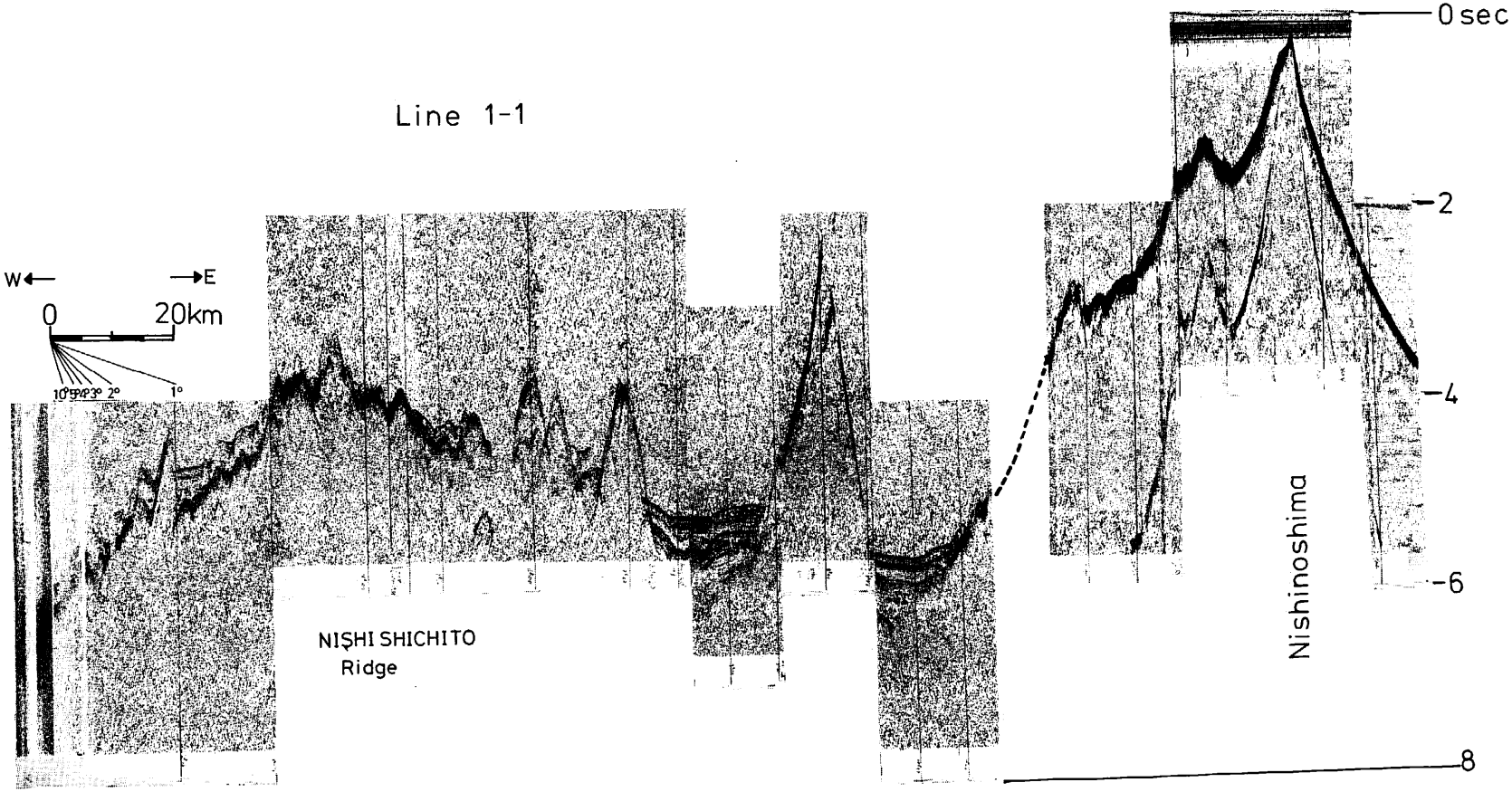
d) Line 2–1

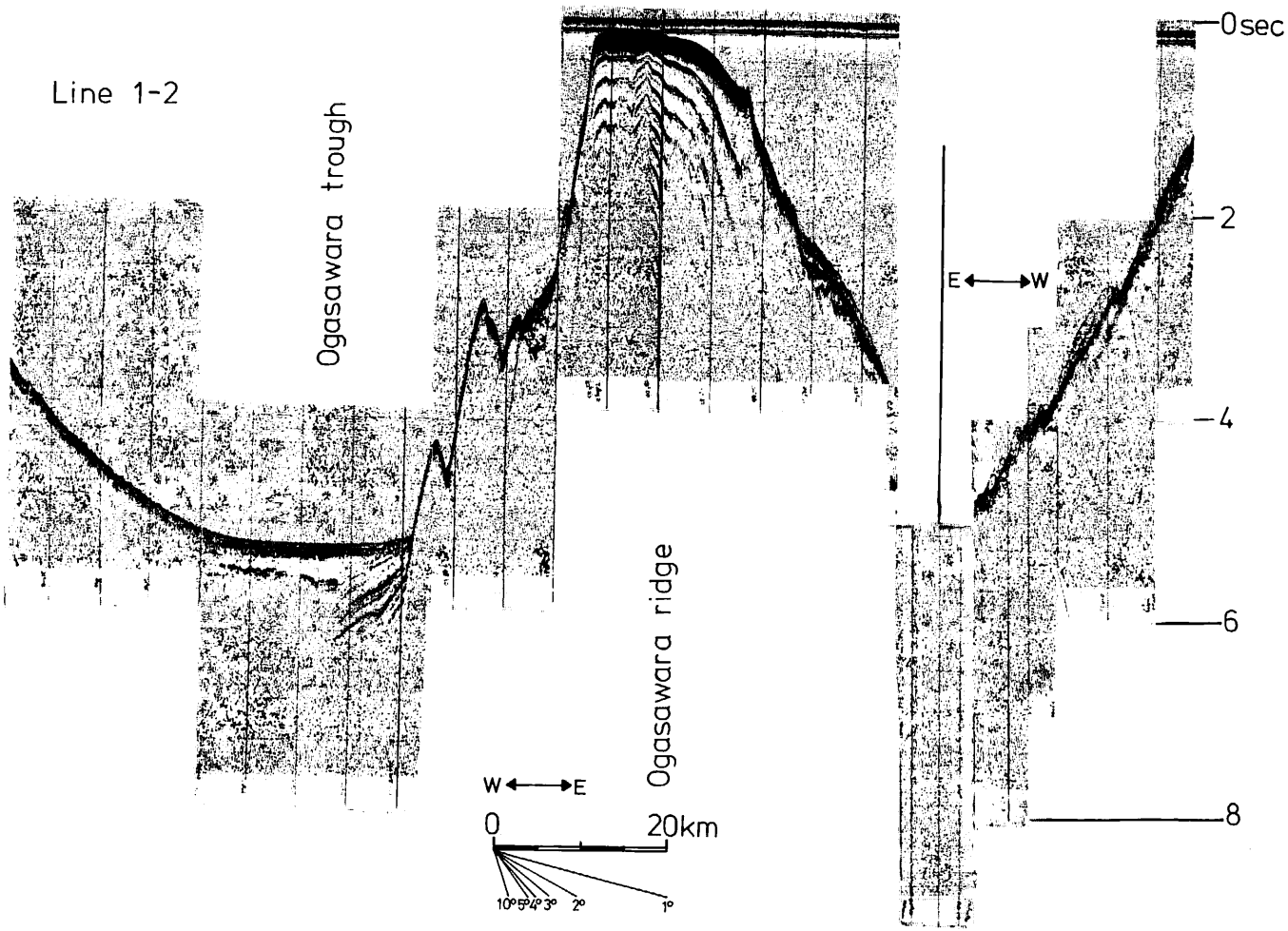
Four typical oceanic layers are distinguished on the Pacific basin floor: namely a transparent layer of approximately 0.1 sec in thickness, an opaque layer of approximately 0.1 sec in thickness and a transparent layer of approximately 0.1 sec in thickness and opaque layer in descending order. On the abyssal plain there are several faults some of which have topographic features of depressions. Two channels similar to those observed in Line 1-3 are present on the floor.

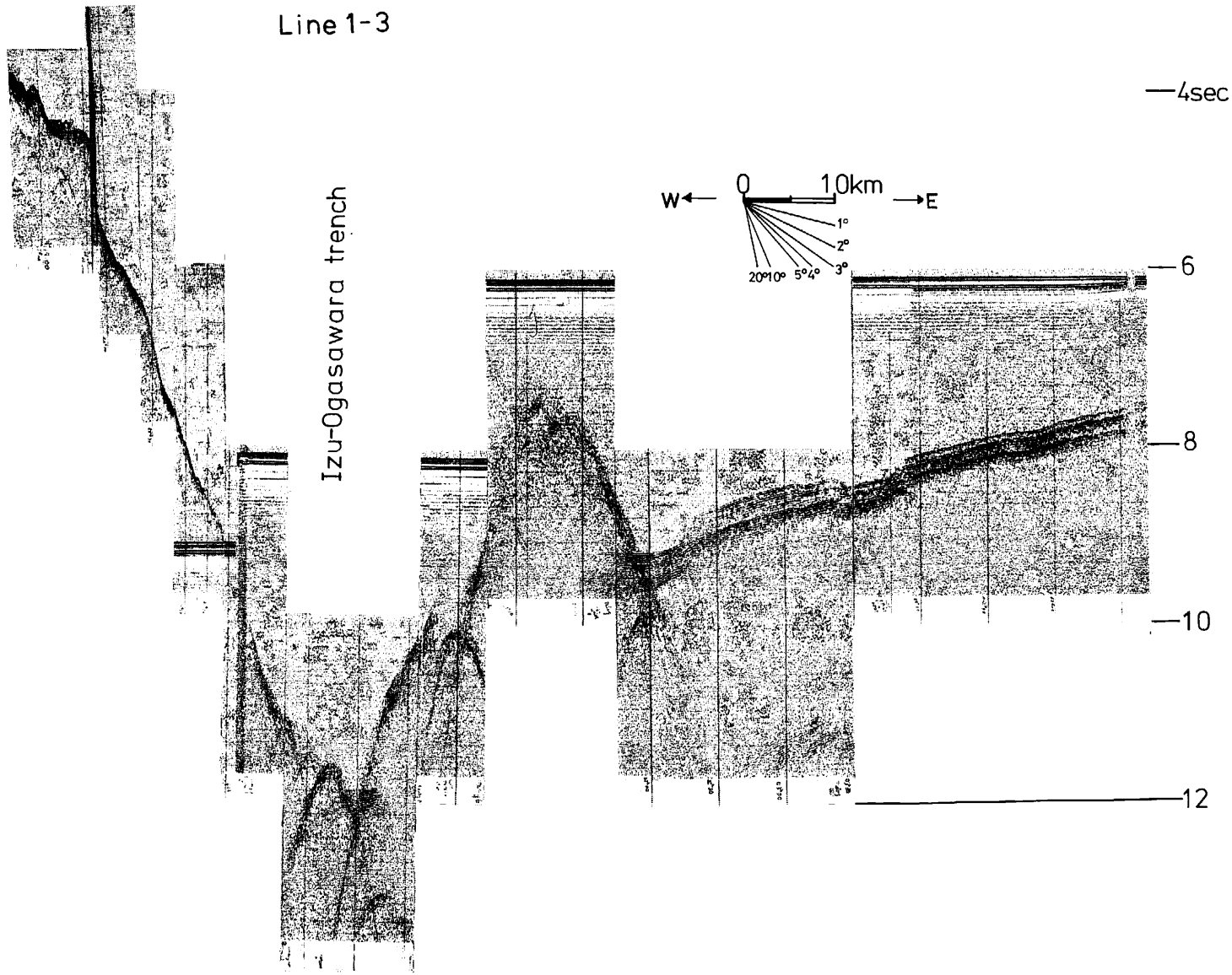
The eastern slope of the Izu-Ogasawara Trench is covered by thin sediments. At the bottom of the trench, sediments with a thickness of 0.5 sec have a flat surface like that of the turbidites are deposited. They are not folded.

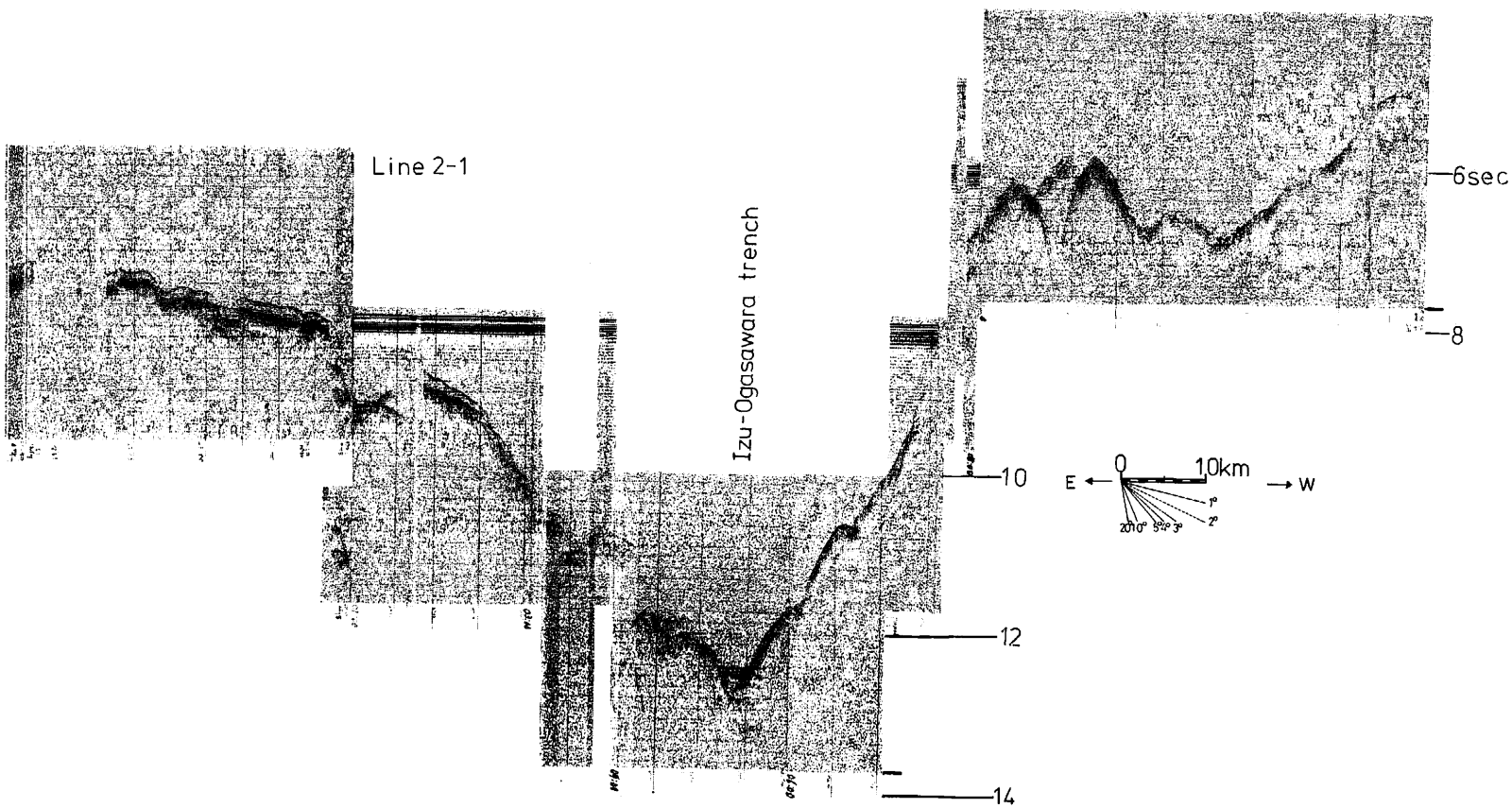
The western slope of the trench is covered by a thin opaque layer extending to the depth of approximately 6.5 sec having three distinct benches. Three swells at a depth of about 6.5 sec are composed mainly of acoustic basements and are correlated with the Ogasawara Ridge.

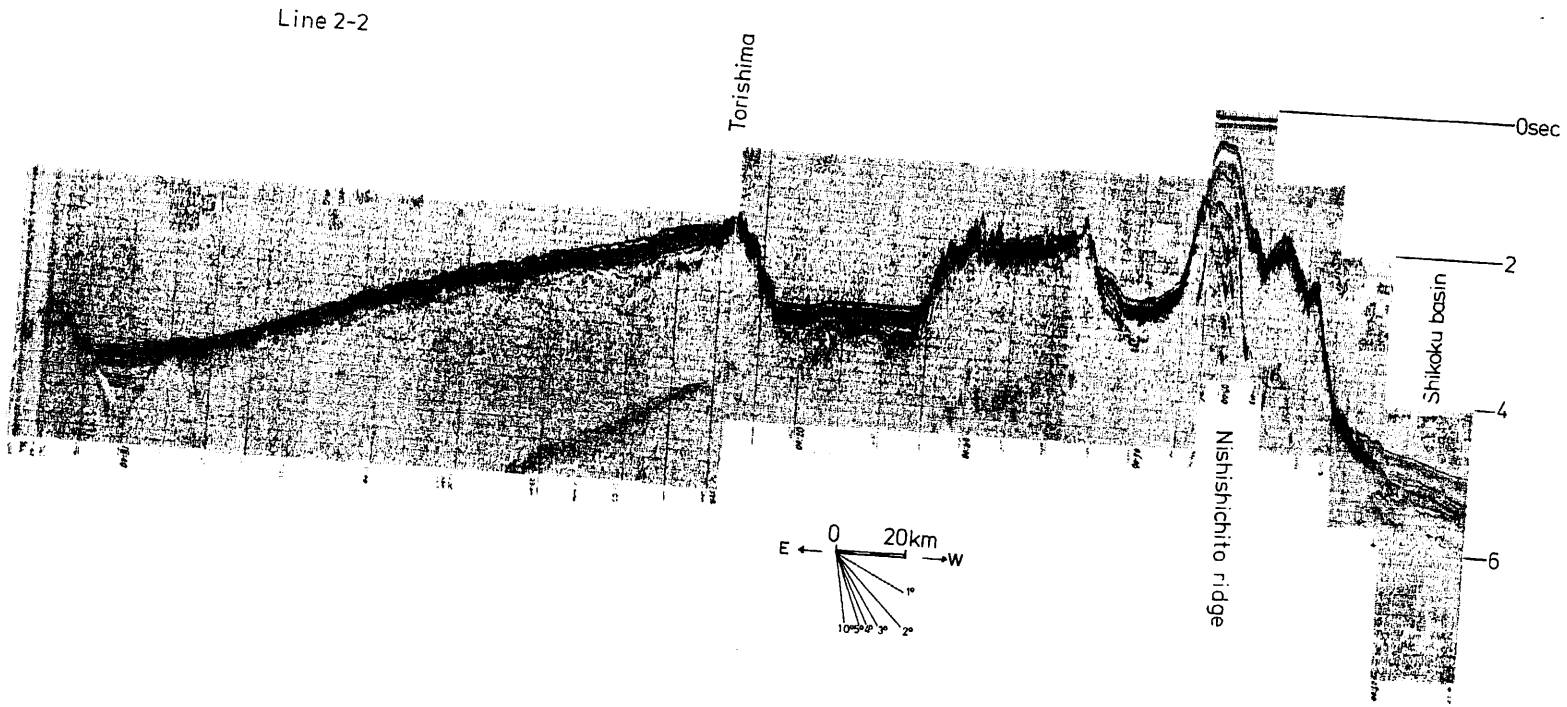
Fig. 14 Seismic reflection profiles across the Izu-Ogasawara Arc and Trench.

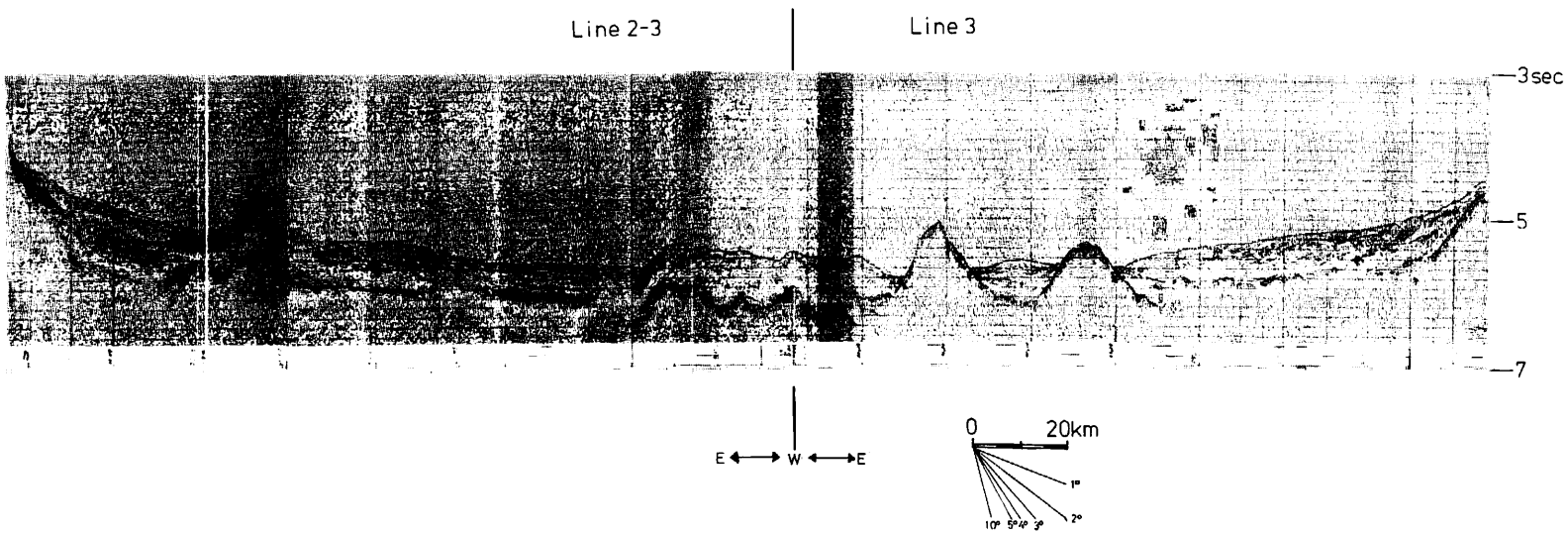


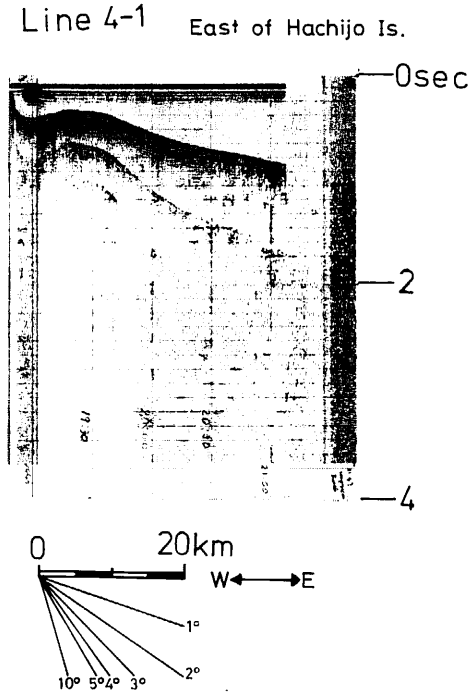

Line 1-2
Ogasawara trough
Ogasawara ridge
W ⟷ E
0
20km
10° 5° 4° 3° 2° 1°
E ⟷ W
0sec
2
4
6
8

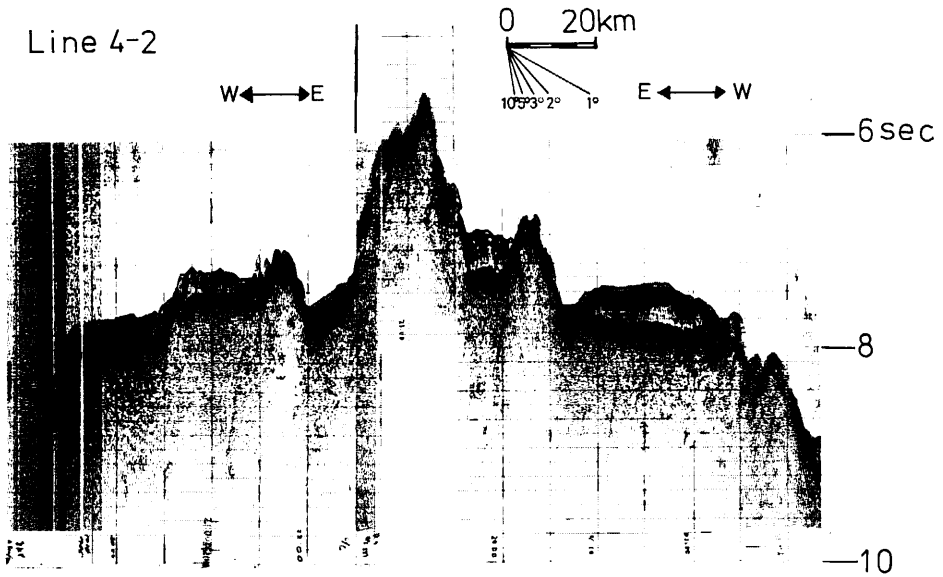

Line 1-3
4sec
W
0
10km
E
1°
2°
3°
20°10°
5°4°
Izu-Ogasawara trench
6
8
10
12

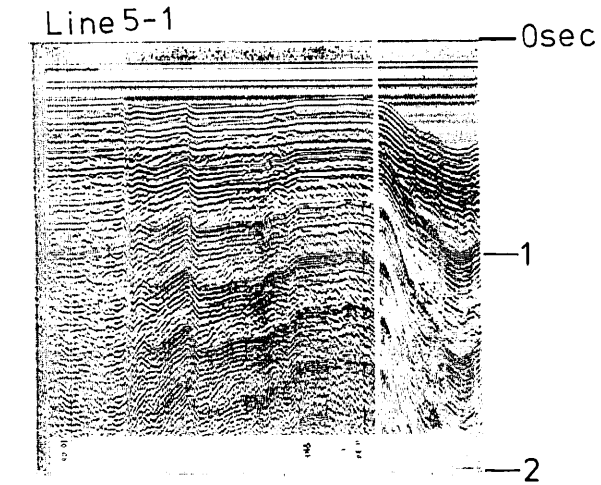

Line 2-1
Izu-Ogasawara trench
6sec
8
10
12
14
E
0
10km
W
1°
2°
3°

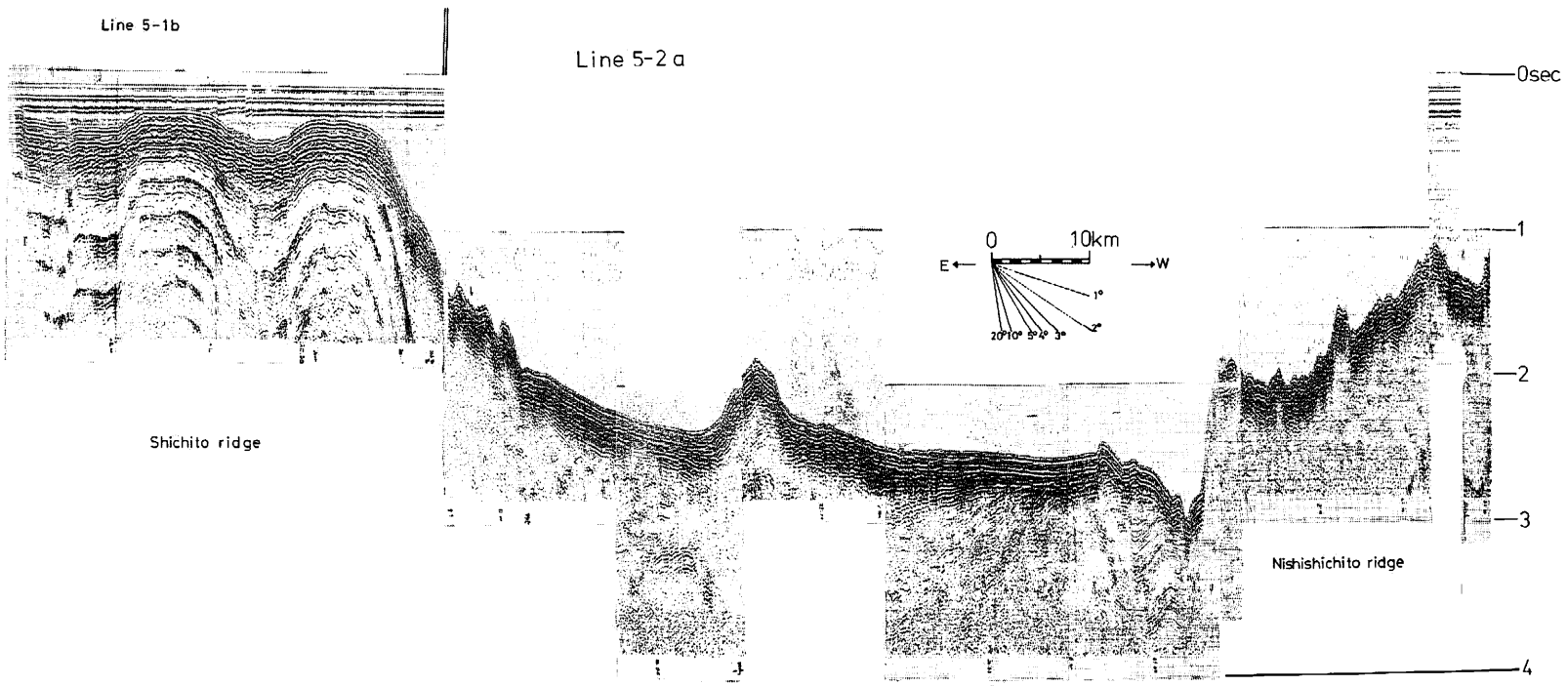

Line 2-2
Torishima
0sec
2
4
6
Shikoku basin
Nishishichito ridge
E
0
20km
W
1°
2°
3°
4°
5°
10°

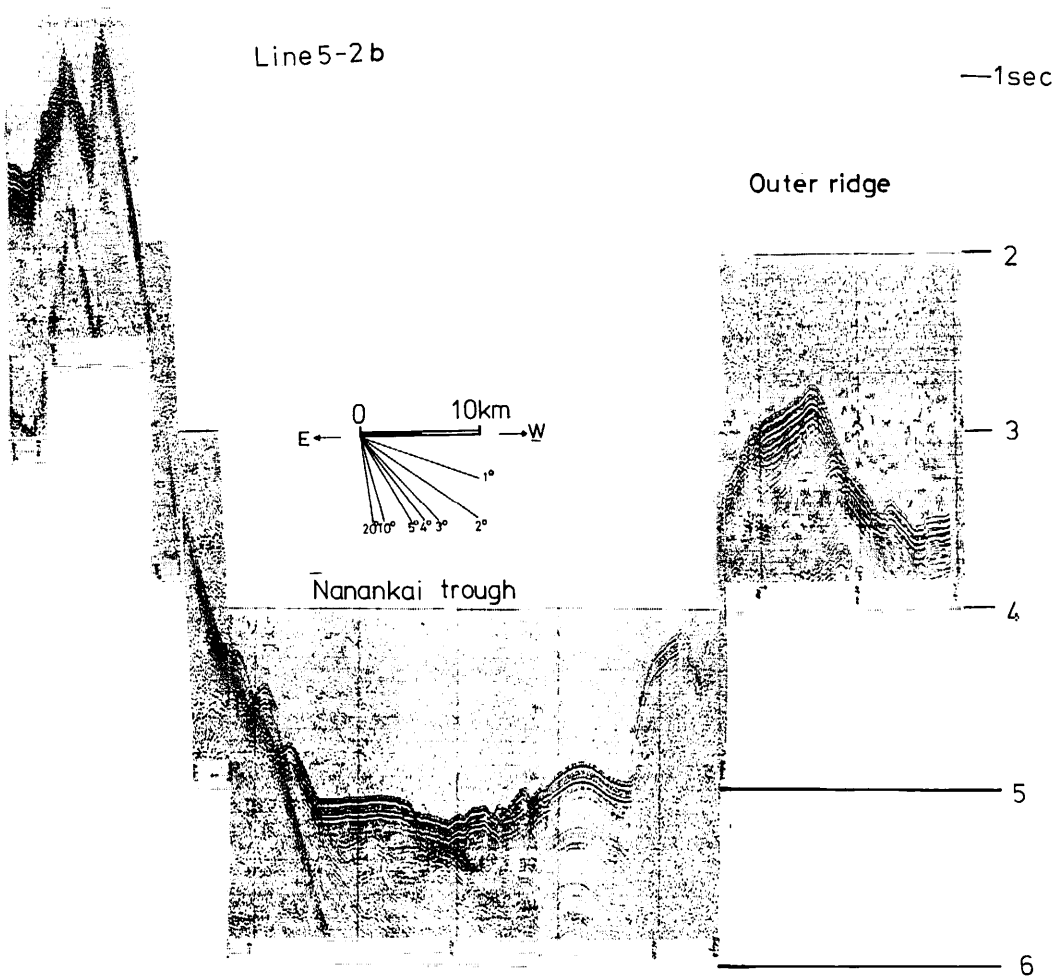

Line 2-3
Line 3
3sec
5
7
E
W
E
0
20km
1°
2°

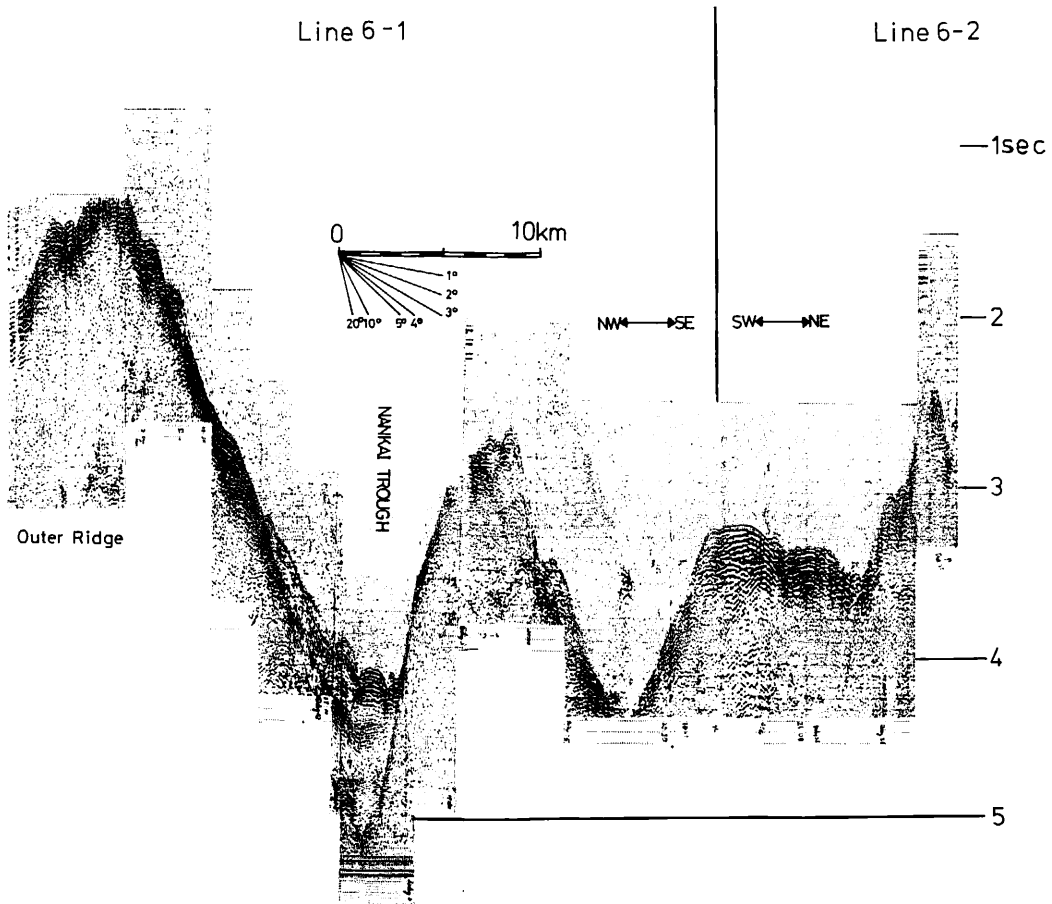

Line 4-1
East of Hachijo Is.
0sec
2
4
0
20km
W
E
1°
2°
10°
5°
4°
3°

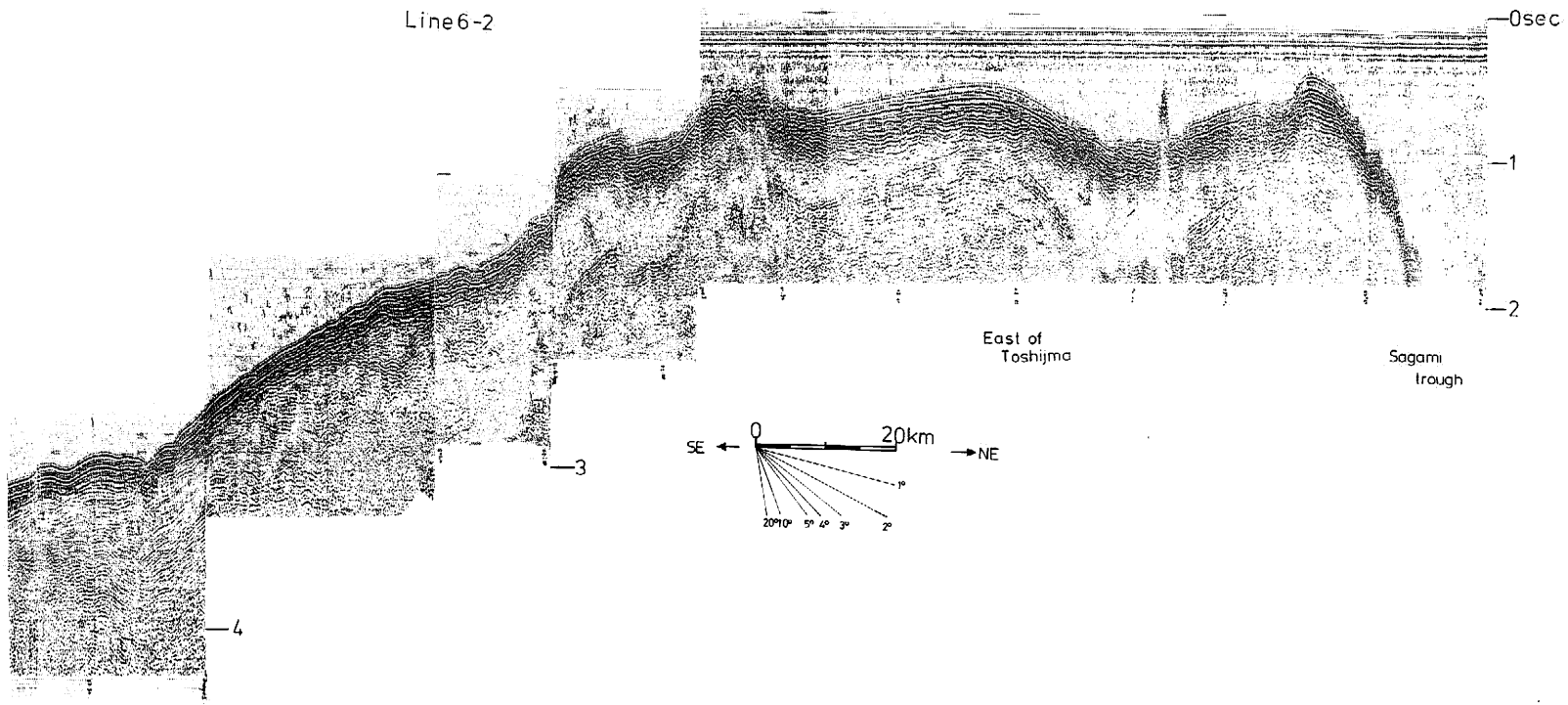

Line 4-2
0
20km
W
E
E
W
10°
5°
3°
2°
1°
6sec
8
10


Line 5-1
0sec
1
2
0
10km
E
W
1°
10° 5° 4° 3°
2°


Line 5-1b
Line 5-2 a
0sec
1
2
3
4
0
10km
E
W
1°
2°
20° 10° 5° 4° 3°
Shichito ridge
Nishishichito ridge


Line5-2b
—1sec
Outer ridge
2
3
4
5
6
0
10km
E
W
1°
2°
3°
4°
5°
10°
20°
Nanankai trough


Line 6-1
Line 6-2
1sec
0
10km
1°
2°
3°
20°
10°
5°
4°
NW
SE
SW
NE
2
3
4
5
NANKAI TROUGH
Outer Ridge


Line6-2
0sec
1
2
3
4
East of
Toshijma
Sagami
trough
SE
0
20km
NE
1°
2°
3°
4°
5°
10°
20°

e) Line 2–2 and Line 3

Sediments in a small basin west of these seamounts have a thickness of approximately 1 sec and are thinner than that in the basin west of the Ogasawara Ridge shown in the Line 1–2. Those sediments at the margin of the small basin are slightly uplifted and suggesting that the basin has been recently subsiding.

The eastern slope of Torishima Island of the Shichito-Iojima Ridge has a rather smooth surface inclining gently eastward.

On the slope a slumped thin opaque layer covers the gently folded transparent layer. The basement of these layers is also inclined eastward and has several small hollows. The western slope of Torishima Island is steep and its surface irregular. These facts suggest that the block of the Shichito-Iojima Ridge in this area is tilted eastward.

Between Torishima Island and the Nishi-Shichito Ridge, there are two basins separated by a broad ridge composed mainly of acoustic basement.

The sediments of the eastern basin are about 0.5 sec in thickness and seem to be turbidites which are gently folded. The basement beneath the sediments in the basin has an irregular surface and appears to be igneous. The broad ridge is mainly composed of acoustic basement and is complicated by irregular topographic features, but in general is gently inclined eastward. The ridge is covered in places by thin sediments presumably composed of recent volcanics.

The sediments of the western basin have a thickness of a little more than 1 sec and their upper part is probably composed of turbidites. The sediments at eastern margin of the western basin encroach on the slope and those at the western margin are also slightly elevated. The young turbidites in the basin are also elevated so that the broad ridge and the Nishi-Shichito Ridge have presumably been uplifted previously or during sedimenta-

Table 6 Stratigraphy of the Shikoku Basin.

	DSDP site 297 (DSDP Scientists, 1973)	Western part of the Shikoku Basin (MURAUCHI *et al.*, 1974)	Eastern part of the Shikoku Basin (GH 74-3 cruise)
Recent	Pelagic sediments	Upper opaque layer	Upper opaque layer
Pleistocene		Upper transparent layer	Upper transparent layer
Pliocene	Terrigeneous turbidites	Lower opaque layer	Lower opaque layer
Miocene	Pelagic sediments	Lower transparent layer	Lower transparent layer

tion.

The sediments on the acoustic basement in the eastern margin of the Shikoku Basin are divided into four layers, namely in ascending order: a lower transparent layer of more than 1 sec in thickness, lower turbidites of approximately 0.5 sec in thickness, an upper transparent layer of about 0.4 sec in thickness and upper turbidites of about 0.3 sec in thickness.

In the western part of the Shikoku Basin, stratigraphic sequences of the basin sediments have been previously established (DSDP scientists, 1973). Therefore age correlation is possible. The lower transparent layer is Miocene, the lower turbidites are Pliocene, the upper transparent layer is Pliocene to Recent and the upper turbidites are upper Pliocene to Recent.

The lower transparent layer, including part of the opaque layer, and the lower turbidites are folded and elevated toward the western slope of the Nishi-Shichito Ridge. The upper transparent layer also encroaches on to the western slope. The upper turbidites are only distributed in the deeper parts of the Shikoku Basin. The irregular topography of the Shikoku Basin, made by the acoustic basement and partly by the lower transparent layer, is smoothed by younger sediments and crops out on the surface of the sea bottom in places.

f) Line 4–1

The thin opaque layer overlies the basement east of Hachijo Island.

g) Line 4–2

There is a seamount east of the Izu-Ogasawara Trench. On the western slope of the seamount three terraces of the acoustic basement are present which are separated by small swells of basement and covered by sediments of approximately 0.1 sec in thickness.

h) Line 5–1

Sediments of approximately 1 sec in thickness are horizontally deposited on the bottom of the Izu-Ogasawara Trench and are presumably turbidites. The western slope of the trench rises steeply to the depth of about 3 sec, and has three typical benches. There is no broader basin which can be correlated to the Ogasawara Trough. The slope gently rises up near Mikurajima Island, and consists of sediments of approximately 1 sec in thickness on the acoustic basement. Around the island older sediments probably Miocene in age, are distributed and intruded by igneous rocks.

i) Line 5–2 and Line 5–3

Thick sediments of more than approximately 1.5 sec in thickness are deposited on the Shichito-Iojima Ridge and the Nishi-Shichito Ridge. The thickness of recent turbidites is less than that of the underlying sediments which are presumed to be folded Tertiary strata. The sediments at the eastern margin of the basin partly cover the slope, but there is a fault between the basin and the Nishi-Shichito Ridge.

The Nishi-Shichito Ridge has an irregular surface which is covered by a thin opaque layer. The ridge is presumably composed of volcanic rocks and rather intensively folded strata. The western slope of the ridge descends steeply to the Nankai Trough. In the trough turbidites are thin and the folded strata beneath the turbidites are thick. The folded strata wedge out on the western slope of the Nishi-Shichito Ridge and thin eastwards.

The outer ridge west of the trough in the Enshunada Sea is presumably composed of

Neogene sediments which are covered by younger thin sediments with an anticlinal structure.

j) Line 6–2

The area between Zenisu Shoal and Oshima Island in the northern part of the Shichito-Iojima Ridge is composed mostly of probable Miocene sediments which are intruded by igneous rocks, covered by thin younger sediments. The sediments in the Sagami Trough are elevated toward Oshima Island, suggesting that they have subsided relative to the active volcanic island.

References

DSDP SCIENTISTS (1973) Western Pacific Floor. *Geotimes*, vol. 18, no. 10, p. 22–25.

HANZAWA, S. (1947) On Planktonic Foraminifera from Okinawa Islands and Ogasawara Islands. *Jour. Geol. Soc. Japan*, vol. 32, p. 461–484.

HOTTA, H. (1970) A Crustal Section across Izu-Ogasawara Arc and Trench. *Jour. Phys. Earth*, vol. 18, no. 2, p. 125–141.

KANEOKA, I., ISSHIKI, N. and ZASHU, S. (1970) K-Ar age of the Izu-Bonin Islands. *Geochem. Jour.*, vol. 4, p. 53–63.

MURAUCHI, S., ASANUMA, T. and SAKI, K. (1974) Mechanism of Sea Floor Spreading in Shikoku Basin, South of Japan. *Mar. Sci. Japan*, vol. 6, no. 12, p. 57–63.